Financial Shocks, Financial Frictions and Financial Intermediaries in DSGE Models: Comments on the Recent Literature

Arend, Mario
Boston College

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Mario Arend*

Department of Economics, Boston College

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Abstract

The aim of this work is to compare and contrast different ways of modeling financial shocks and financial intermediaries in the Dynamic Stochastic General Equilibrium models (DSGE models) and to discuss the empirical evidence on the importance of modeling financial sector and financial shocks in the economy. The analysis is based on four papers on the matter Jerman and Quiadrini (2009) [9], Christiano, Motto and Rostagno (2006) [5] , Goodfriend and McCallum (2007) [8] , and Gertler and Kiyotaki (2009) [7].

Keywords: Financial frictions; Financial Intermediaries; Financial shocks, DSGE models.

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*e-mail: arendser@bc.edu

1 Introduction

The motivation of Jerman and Quiadrini (2009) [9], Christiano, Motto and Rostagno (2006) [5], Goodfriend and McCallum (2007) [8], and Gertler and Kiyotaki (2009) [7] has a common ground which is that in the macroeconomic literature little attention has been given to the interaction between the financial sector and the macroeconomic variables, where usually financial intermediaries are treated as veil. However, over the last decades there has been a stream of literature which has emphasized the role of financial frictions on the aggregate economic activity. The main works on this line are Bernanke and Gertler (1989) [1], Bernanke and Gertler (1995) [2], Kiyotaki and Moore (1997) [10], Carlstrom and Fuerst (1997) [4], Bernanke, Gertler and Gilchrist (1999) [3], Kocherlakota (2000) [11], Cooley, Marimom and Quadrini (2004) [6]. The main finding of these stream of papers is that financial frictions play a key role explaining the evolution of macroeconomic aggregate variables.

There are two distinct important concepts on the effect of the financial sector on economic activity that have to be clarified in order to understand the focus of the papers under study. The first concept is financial frictions, which is a channel where different shocks are propagated to the rest of the economy and as a result the effects could be amplified or attenuated given its presence. The second concept is financial shocks, which is as its name says a shock directly originated in the financial sector of the economy and has the potential to impact the rest of the variables in the economy. The four papers under study include both concepts in their models. However, the work of Jerman and Quiadrini (2009) [9] is the only one which does not consider a financial intermediary (bank) in its framework.

The main focus of this work is to compare and contrast different ways of modeling financial intermediaries. Therefore special attention will be given to the works of Christiano, Motto and Rostagno (2006) [5], Goodfriend and McCallum (2007) [8], and Gertler and Kiyotaki (2009) [7]. However, the work of Jerman and Quiadrini (2009) [9] is also analyzed given the importance of financial frictions and financial shocks in its model.

The striking finding of these papers is that financial sector plays a crucial role in explaining the evolution of macroeconomic aggregate variables. In particular, models that include financial sector (with or without modeling financial intermediaries) are able to explain more accurately the major downturns and booms of the last decades economic events in length and depth. Also, it is found that financial shocks are as important (or more) as the standard productivity technology in driving the major macroeconomic variables in the economy.

In section 2 I describe the models of the works under study and its dynamics paying special attention to its distinctive features and differences. Section 3 discusses empirical evidence on the importance of financial shocks, financial frictions and financial intermediary

modeling. Finally, section 4 concludes.

2 The Models

Among the papers under study Jerman and Quiadrini (2009) [9] is the only one that does not consider a financial intermediary in its modeling. However, the financial sector plays a crucial role in capturing the key dynamic features of the business cycle as well as the behavior of financial flows such as equity payouts and debt payouts. In this paper the economy is composed by two continuum of agents: households and firms. As usual household maximizes their utility function depending on consumption and labor subject to a standard budget constraint which includes equity shares and bonds issued by firms, which are the way firms obtain financing. On the other hand, firms maximizes their equity value subject to two important constraints in this model: i) a budget constraint which contains a quadratic cost for firms payout (considered the financial frictions of the model), which accounts that issuing equities to obtain financing is more costly than issuing debt, and ii) an enforcement constraint in which the fraction that can be recovered in the sale of a defaulting firm (considered the financial shock in this model) plays a crucial role in determining the credit conditions for the firm. If the lender (household) can recover only a very small fraction of the value of a defaulting firm, the credit conditions for the firm will be tight.

From the budget constraint of the firm the financial frictions arrive in this model. In particular, assuming that firms can just issue equities to finance any extraordinary negative liquidity event, a higher cost of issuing equities relative to bonds will make firms to cut labor in order to have enough liquidity to operate according to its plan, this cut in labor will affect the economic activity. Here the parameters governing the cost of issuing equities relative to debt play a crucial role in the financial friction of the model, specifically this parameters are tax benefit for issuing bonds (tax advantage for bonds make debt preferred to equity for financing) and a cost parameter for issuing equities (captures rigidity of adjustment of funds issuing equities and could be interpreted as an agency problem between managers and owners of a firm). On the other hand, as mentioned above financial shocks arrive from the enforcement constraint of the firm, specifically from a random variable which measures the fraction of the value of the firm that can be recovered from a defaulting firm. Here the key issue is that the credit conditions of the firm could be worsened if this fraction of recovery is low (lenders are willing to make more loans if they can recover a higher portion of the firm under default).

All together, a financial shock that worsen credit condition in this model will have a negative effect on labor and output only if there exist financial frictions, (only if it is more

costly for the firm to finance via issuing equities relative to bonds). As we can see, the key issue here is on the side of the firm and not the lender. It is the firm who possibly has an agency problem between its managers and owners which creates the financial friction (issuing equity is costly). Also, the characteristics of the market plays a crucial role since the recovery value of a defaulting firm is exogenous (here institutions and laws that permit lenders to have more power in recovering value in case of default could enhance credit conditions in the market).

The other three paper explicitly model financial intermediaries (banks), but in remarkably different ways. On one hand, Goodfriend and McCallum (2007) [8] and Gertler and Kiyotaki (2009) [7] create financial frictions on the side of the lender (financial intermediaries). On the other hand, Christiano, Motto and Rostagno (2006) [5] create financial frictions on the side of capital managers individuals (entrepreneurs) and not the lender (financial intermediaries). Therefore, an important distinction between these models is in which sector the financial friction is created. Other aspect of the models that account for substantial difference are financial shocks. In Gertler and Kiyotaki (2009) [7] although there is space to create a financial shock (I will discuss this point later), the authors just consider one type of shock which is not created in the financial sector of the economy, which is a capital quality shock. On its part, Christiano, Motto and Rostagno (2006) [5] and Goodfriend and McCallum (2007) [8] consider explicitly financial shocks in the economy. In the model of Christiano, Motto and Rostagno (2006) [5] there are three shocks related to the financial sector of the economy: i) financial wealth shock (financial friction shock) , ii) banking sector technology shock (financial intermediary shock), and iii) relative value of excess reserves shock (financial intermediary shock). In the model of Goodfriend and McCallum (2007) [8] there are two types of shocks related to the financial sector of the economy: i) banking productivity shock or loan productivity shock (financial intermediary shock) , and ii) effective collateral shock or financial distress shock (financial intermediary shock).

I will now discuss Goodfriend and McCallum (2007) [8] model. As was mentioned above this model creates financial frictions on the side of the lender (financial intermediaries) and has two types of shocks related to the financial sector. There are three agents in the economy household, firms and bank. The optimization problem of the model is solved in one step for the households who are owner of the firms and bank. Households maximizes an utility function which depends on consumption and labor (for firms and bank), subject to three constraints: i) a budget constraint which incorporates high-powered money (which equals reserves at the central bank) and government bonds, ii) sales equal to net production constraint (needed to reflect monopolistic competition in the goods market), and iii) money medium of exchange constraint, which requires that consumption must be related to deposits,

which are the same time related to loans (considering also reserves at the central bank from the balance sheet of the bank), and where loans have a specific production function (which is the 'analytical heart of the banking sector specification'). The production function for loans depend on a combination of collateral (bond or capital, where bonds are more productive) and labor. The two financial intermediary shock arrive in the production function for loans, one making capital collateral more effective in producing loans and the other increasing productivity of loans. Notice that since loan production is costly for the bank, an 'external finance premium' which equals the real marginal cost of loan production arrives in the model (external finance premium).

Regarding the mechanism of transmission of model the key ingredients come from including a demand for money (money medium of exchange constraint) and a production function for loans which includes collateral, this collateral creates financial frictions. To understand why collateral will cause financial frictions assume that there is decrease in the economic activity which pushes asset prices down and therefore pushes value of collateral down. Given this events we will have to different transmission mechanism: i) accelerator, in which the decrease in the value of collateral will increase the 'external finance premium' for a given quantity of bank deposit demanded (can be seen as negative effect on loan supply curve that shit it left), and ii) attenuator (particular for this model with demand for money), in which the decrease in the economic activity will decrease the demand for deposit (decrease demand for collateral) tending to drop the 'external finance premium' for a given value of collateral (can be seen as a negative effect on the demand for loans that shift it left). The equilibrium between supply and demand for banking services will determine the 'external finance premium', which at the same time will affect the rest of the rest of the variables of the model. Therefore, depending on the type of shock the financial friction (created in part by collateral and also by introducing a demand for money) will have an accelerating or attenuating effect in the economic activity. A policy implication is that a central bank unaware of this mechanism could misjudge the effects of shocks in the economy given a determined policy rule. The model also finds that the effects of the two financial intermediary shocks (productivity in banking sector and financial distress) are major drivers of the macroeconomic variables in the model, and therefore a central bank unaware of this mechanism will misjudge its behavior.

As we can see in Goodfriend and McCallum (2007) [8] model financial sector plays a crucial role in explaining the dynamics of the economic variables. The way the introduce the financial sector is by explicitly incorporating a bank in the model with two key feature that makes a difference respect to other papers under study: i) money demand, and ii) collateral in the production function. Its worth mentioning that he existence of money and

banking in this model will create a 'liquidity service yield' for loans with collateral, therefore interest rates for this loans will be lower than a default free instrument with no collateral. Also money and banking in the model will force interbank interest rate to be lower than the default free instrument with no collateral (they can not be equal given that this would produce an excess supply of interbank credit).

The next model to be discussed is Gertler and Kiyotaki (2009) [7] where financial frictions are created on the side of the financial intermediary and there are no financial shocks taken into account. In this model the economy is composed of one household with a continuum of individual who maximize an utility function on consumption and labor, the budget constraint includes deposits to the banks, there are two classes of continuum of firms located at a continuum of areas: i) good producers who contract labor and capital to produce goods, and ii) capital producers who face convex adjustment costs at producing new capital, and there are also a continuum of banks located at different areas who captures deposits from the public or funds from other banks in order to make loans in its area. The model is very standard with respect to household and the two classes of firms, the key ingredient of the model arrives in the banking sector where there is an agency problem given that at the end of each period a banker may divert a fraction of deposits to its family. If a banker divert this funds for its personal gains shut downs and creditors get just a fraction of their deposits from the bank. As I mentioned before there is enough space in this model to test financial shocks, although the authors don't do it. One possible financial shock that could be incorporated to the model is randomize the probability that banker exits next period and the other financial shock that could have been incorporated is a randomization of the fraction that a bank can divert to its family. However, the authors treat this two financial shocks as constant parameters.

The agency problem generated in the banking sector will cause the financial friction in this model. Particularly, since creditors recognize the bank's incentive to divert funds, they will restrict the amount they lend to the bank (bank face a borrowing constraint), and banks will have less available funds to lend to the firms, which will affect the aggregate activity in the economy. The agency problem could potentially affect the interbank and household channel for the bank to obtain funds to lend.

The bank optimization problem of this model consist in the maximization of the value function of the bank subject to an incentive constraint (to ensure that bank does not divert funds) and a flow of funds (loans equal net worth plus deposits and interbank borrowing). From the optimization problem of the bank we can manipulate the parameters in order to generate the agency problem in household channel and also in the interbank channel, where banks obtain funds to lend to the firms. A key aspect of the model is that firms obtain

financing from the banks by issuing equities. In the case that net worth is reduced for any given shock (the authors use a quality of capital shock) the incentive compatibility constraint will become tighter which will heighten the agency problem, which will make banks to have less available funds to lend to firms, and therefore they will not be able to buy as much equity from the firms, bringing the price of capital down and also bringing interest rates up (which can be understood as a contraction of the supply of loan funds). This increase in the interest rate will propagate the negative effect in the economy and we will observe a sharpen decline of the key macroeconomic variables such as output and investment. The problem becomes more severe when the agency problem also exists in the interbank channel.

The authors propose three different types of unconventional credit policy to mitigate the crisis, based on what the Federal Reserve has done during the recent financial crisis. Each of these policies has advantage and disadvantage which will lead the central bank to use a combination of them. One way to mitigate the crisis would be direct lending by the acquisition of private securities by the central bank, in which case the central bank injects funds directly to the firms. Other policy is opening a discount window lending in which case the central bank lends funds to the financial intermediaries, and this way banks will be able to acquire more equities from firms in the market. The other policy measure that could be used to mitigate the crisis is equity injections where the central bank acquires ownership position in banks paying a higher price and this way injecting funds and raising asset demands by banks.

As we can see Gertler and Kiyotaki (2009) [7] generate the financial friction problem in the financial intermediary sector, but in contrast to Goodfriend and McCallum (2007) [8] the problem is created in the channel between household (and also interbank market) and banks and not between firms and bank (collateral).

Finally, I will discuss Christiano, Motto and Rostagno (2006) [5] where financial friction is created on the side of the entrepreneurs and there are there are three shocks related to the financial sector of the economy: i) financial wealth shock (financial friction shock) , ii) banking sector technology shock (financial intermediary shock), and iii) relative value of excess reserves shock (financial intermediary shock). Before, explaining the model is worth mentioning that this paper covers too many issues. Therefore, as has been done with the other papers I will just focus on the financial friction and financial shocks of the model. In this model the economy is composed by a continuum of agents who maximize utility on consumption, labor and a broad category of money (currency, saving deposit, and demand deposits), subject to a budget constraint which includes different types of deposits: i) saving deposits, ii) time deposits, and iii) demand deposits), where the last two generate transaction services, also a demand for labor a Calvo wage settings are considered in this optimization

problem for the household. There are also other type of individuals which are called the entrepreneur who have a key characteristic to know how to manage capital and therefore are able to expand capital in the economy. This entrepreneurs, use loans and net worth to purchase new capital, which they will use for rent (is easier to imagine imagine entrepreneurs as buildings owners who rent capital to capital producers). Another key characteristic in modeling entrepreneurs is that they face a random survival probability (which will be authors to account for the financial friction shock), an increase in this probability is as a positive financial wealth shock for the entrepreneurs who are now able to purchase more capital, which will increase the capital price and their net worth, driving output, investment and consumption up. There are also two classes of continuum of firms in the economy: i) good producers, which optimize discounted profits in a standard way (they produce consumption and investment goods), and ii) capital producers, who rent capital and purchase investment goods (e.g. machinery) from goods producers to create new capital, again the optimization problem is standard. Finally, there is a representative bank who is able to produce transaction service for firms and entrepreneurs by obtaining funds from different types of liabilities as mentioned before (saving deposits, time deposits, and demand deposits), which will create different types of monetary aggregates in this economy. The production of transaction services is characterized by a production function which considers capital, labor and excess reserves to produce loans. In this production function is where financial intermediary shocks arrive, one is a banking sector technology shock the other is a relative value of excess reserves shock.

The financial friction mechanism plays a crucial propagation effect on the variables in this model, given any shock that drive the price of capital down (including a negative financial friction shock) by the called 'Fisher debt-deflation channel' entrepreneurs will be transferring funds to the households, and since household do not know to manage capital there will be an additional negative effect in the economy. Therefore, the financial friction mechanism is generated by the 'Fisher debt-deflation channel'. Other important feature of the model is that not including banks will have little effect in most of the variables, except on shocks on monetary policy. On its part, financial intermediary shocks have no major impact in the variables of the model. The most important finding of the model is that the financial friction shock (given by the probability of entrepreneur survival) is on of the most relevant drivers in the business cycle dynamic of the model. Therefore, in this model financial frictions and financial frictions shocks are the key variable that explain the business cycle fluctuations. Finally, the authors find that including the banking sector in the model and its shocks have little effect in this model. This results of the authors lead us to discover the most important aspect of models that include the financial intermediaries, which is that in order that financial

intermediaries to have an important role in propagating the shocks in the economy the financial frictions of the model have to be introduced in the financial intermediary sector of the economy, otherwise incorporating financial intermediaries is equivalent as treating them as veil.

3 Empirical Evidence

The empirical findings of Jerman and Quiadrini (2009) [9] are that models considering just technology shocks are not able to explain the business cycle fluctuation of real and financial flows variables for the U.S. economy. In incorporating financial shocks improve the model predictions for macroeconomic variables (especially labor) and financial flows variables. Specifically, financial shocks permits to explain the recent financial crisis and also the downturns in the recessions of 1990-1991 and 2001. As conclusion, tighter credit conditions have a crucial role in explaining the recession for the U.S. economy since mid 1980s. Studying the second moments we are able to conclude that incorporating financial shocks to the model with financial frictions permit us to match the volatility some variables with the data for some key macroeconomic variables such us GDP, Investment, hours worked.

In Goodfriend and McCallum (2007) [8] it is found that incorporating money and banking to the model permits to fit in the steady state the aggregate variables and interest rates to the U.S. observable data. The model is specially successful in its steady state matching the data for working time, capital output ratio, interbank rate, collateralized external finance premium.

On its part, Gertler and Kiyotaki (2009) [7] are able to find that for the recent U.S. financial recession a shock that triggers the financial friction (negative capital quality shock) of around 5% permits us to explain the deep downturn of the U.S. economy. Under standard business cycle model this is not possible since models fall short in explaining the fall in the macroeconomic aggregates during this crisis.

Finanlly, Christiano, Motto and Rostagno (2006) [5] compare the out of sample performance of their model for U.S. and the European Area (E.A.) . Using the root mean square forecast error criterion they find mixed results for the different macroeconomic variables, in some cases their model outperform other models in forecasting the variables of the model but in some other cases not. Paying particular attention to the GDP forecast we observe that for the E.A. their model behaves similar than other models (it does not better predicting GDP), for the U.S. the performance of their model in predicting GDP does reasonably well. Other key finding of their model is that for E.A. and U.S. a key driver of the GDP fluctuation is the financial friction shock. Finally, their models permits to give an explanation to the

'boom-bust puzzle' of late 90s and early 2000s by combining financial friction shocks and the marginal efficiency of investment shock.

4 Conclusions

The discussion of the models analyzed in this work lead us to conclude the following:

1) DSGE models that consider financial sector perform better in explaining real macroeconomic variables than the standard DSGE models.

2) There is still little agreement in how to model the financial intermediaries.

3) There is no agreement on whether to focus the attention of financial disruption, which could be between: i) household and banks, ii) banks and other banks, iii) entrepreneurs and banks, or iv) firms and banks.

4) It is not clear whether incorporating an explicit financial intermediary shock makes a real contribution to the model given that financial frictions in the financial intermediary sector are able to propagate other types of shocks in the economy considerably well.

5) The main conclusion of this analysis is that in order that financial intermediaries play a significant role in the economy the financial frictions have to be incorporated inside the financial intermediaries sector, otherwise financial intermediaries will make no difference in the model.

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